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Deforestation and Shade Coffee in Oaxaca, Mexico

Key Research Findings

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Deforestation and Shade Coffee in Oaxaca, Mexico: Key Research Findings

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Abstract

More than three-quarters of Mexico's coffee is grown on small plots shaded by the existing forest. Because they preserve forest cover, shade coffee farms provide vital ecological services including harboring biodiversity and preventing soil erosion. Unfortunately, tree cover in Mexico's shade coffee areas is increasingly being cleared to make way for subsistence agriculture, a direct result of the unprecedented decline of international coffee prices over the past decade. This paper summarizes the key findings of a three-year study of deforestation in Oaxaca, one of Mexico's prime regions for growing shade coffee. First, we find that deforestation during the 1990s was significant. Second, the loss of tree cover can likely be slowed by promoting coffee-marketing cooperatives and "green" certification, providing coffee price supports, and specifically targeting areas populated by small, indigenous farmers for assistance. Finally, to be effective, such policies must be implemented quickly after price shocks occur.

Key Words: deforestation, agroforestry, shade-grown coffee, Mexico, land cover

JEL Classification Numbers: O13, Q15, Q23

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Deforestation and Shade Coffee in Oaxaca, Mexico: Key Research Findings

Allen Blackman, Heidi Albers, Beatriz Ávalos-Sartorio, and Lisa Crooks*

1. Introduction

More than three-quarters of Mexico's coffee is grown on small plots shaded by the existing forest (Rice and Ward 1996). Because they preserve forest cover, shade coffee farms provide vital ecological services including harboring biodiversity, sequestering carbon, facilitating aquifer recharge, and preventing soil erosion (Perfecto et al. 1996; Rice and Ward 1996). The biodiversity benefits of shade coffee are particularly notable because the crop generally grows in coastal mountain ranges at altitudes where tropical and temperate climates overlap. Such areas are extremely biodiverse. In fact, the Mexican government has designated all 14 of the country's main shade coffee–growing regions as biodiversity hotspots (Moguel and Toledo 1999).

Unfortunately, Mexico's shade coffee areas are increasingly being deforested, and these important ecological services are being lost. A root cause of this deforestation has been the so-called coffee crisis—the steep decline of international coffee prices over the past decade. (A second important cause has been the shuttering of INMECAFÉ, Mexico's coffee marketing board, which until 1990 provided price floors and low-cost credit to coffee farmers.) The coffee crisis has forced shade coffee growers, who are among Mexico's poorest farmers, to find alternative sources of income. Some have migrated to cities to find employment, abandoning their farms and leaving them vulnerable to encroachment by conventional farmers, ranchers, and loggers. Others continue to grow coffee but have cleared forest on and around their farms to sell the timber and grow corn and beans (Ávalos and Becerra 1999). Whatever the specific cause, ecological damage from deforestation in shade coffee regions can be significant, and some of it—notably species loss and soil erosion—may be irreversible or nearly so.

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Policymakers are increasingly concerned about the loss of Mexican shade coffee. Several international organizations have established high-profile programs to address the problem. For example, the Commission for Environmental Cooperation (CEC), a tri-national environmental agency created by the North American Free Trade Agreement, has developed a program to promote shade coffee in Mexico (CEC 1999). Also, Conservation International, Starbucks, and the World Bank have joined forces to promote shade coffee near the El Triunfo Biosphere Reserve in the state of Chiapas.

Despite such efforts, we know little about the causes, process, extent, and location of deforestation. Such information could help stakeholders design more efficient and more effective policies to stem the decline of forests in shade coffee regions.

Over the past three years, Resources for the Future (RFF), a nonprofit research institute in Washington, DC, and Universidad del Mar–Puerto Ángel (UMAR), a public university in Oaxaca, Mexico, have undertaken research to help fill this knowledge gap. Focusing on a study area in the Sierra Sur y Costa region, the RFF–UMAR research addressed five related questions:

- Before the coffee crisis (in 1993), what factors explained spatial patterns of deforestation in shade coffee forests?
- Before the coffee crisis (in 1993), how did spatial patterns of deforestation in shade coffee forests differ from spatial patterns of deforestation in nearby natural forests?
- How much deforestation occurred in shade coffee forests after the onset of the coffee crisis (1993–2001)?
- What factors explain spatial patterns of deforestation in shade coffee forests after the onset of the coffee crisis (1993–2001)?
- What drives farmers to abandon shade coffee plantations, and how can abandonment be prevented?

In this paper, we describe the research that the RFF–UMAR team has undertaken to answer these questions, present the key findings from our research, and discuss the policy implications of our findings.

2. Study Area

The Sierra Sur y Costa region in the state of Oaxaca produces about one-fifth of Mexico's coffee. Three-quarters of the region's coffee acreage is managed by poor, small-scale farmers using shaded systems (Nestel 1995). Our study area consists of a 634,000-hectare subset

of this region (Figures 1 and 2). Within our study area, coffee grows in a 254,000-hectare "coffee range" at 400–1,600 meters above sea level (msl). The entire study area comprises 1,155 towns in 43 *municipios* (counties), while the coffee range comprises 427 towns in 33 *municipios.* The entire study area includes nine cities with populations exceeding 2,000, the largest of which are Puerto Escondido, Zicatela, Pochutla, Santa María Huatulco, and La Crucecita, all located on the coast. The 7,214-hectare Parque Nacional Huatulco, located just west of La Crucecita, is the only protected region within the larger study area. It lies well below the coffee range and therefore contains no shade coffee farms.

Coffee fruit called cherries grow on small tropical evergreen trees. In shaded systems, cherries are picked by hand, typically with the assistance of hired labor. After harvest, the pulp of the cherry is removed, and the seeds—coffee beans—are sorted and dried to produce an intermediate product called *pergamino.* In our study area, growers transport their *pergamino* by donkey or truck to the nearest *cabecera* (county capital), where they sell it to middlemen or marketing cooperatives. From there, the middlemen and cooperatives ship the *pergamino* by truck to one of two large coffee market towns—Oaxaca City or Pochutla—where they sell it to large-scale buyers and exporters. Roads in our mountainous study area are exceptionally poor, and transportation is costly. Because they have to cover the costs of transporting *pergamino* to Oaxaca City and Pochutla, middlemen and cooperatives pay significantly lower prices for *pergamino* in *cabeceras* that are relatively far from these two cities (Ávalos and Becerra 1999). Hence, coffee growers in remote areas earn a lower return on their coffee. Very little of the shade coffee in our study area is certified as such, and as a result, growers and middlemen typically receive no price premiums related to this attribute.

In 1991, the most recent year for which data are available, our study area contained 6,700–8,200 coffee farms that produced approximately 39,000 tons of coffee cherry annually. These farms—all of which employ shade coffee systems exclusively—covered 37,000–53,000 hectares, about 6–8% of the land in the entire study area and 15–21% of the land in the 400–1,600 msl coffee range. In the same year, 43,305 hectares of the entire study area were planted in noncoffee agriculture (approximately 7% of the entire study area). More than two-thirds of this agricultural land was planted in corn, about one-sixth in bananas, and one-sixth in beans.

Within the coffee range, most forest clearing appears to result principally from shifting agriculture. According to local stakeholders, rural households often clear small plots so they can market the timber and grow subsistence crops. However, the poor soils on these cleared plots—which typically are steeply sloped—are quickly eroded by rainfall. As a result, shifting farmers typically move on to new plots within a few years. Our land use data from the early 1990s

(described below) are consistent with this explanation. Within the coffee range, the majority of the cleared plots were smaller than 1.5 hectares, and more than half of these cleared plots were fallow.

Under Mexican law, all persons wishing to clear forested land must obtain a federal permit and in some cases a local permit, regardless of scale of the clearing (NACEC 2003). However, persons clearing small plots for agriculture commonly ignore these requirements. Enforcement of forestry laws depends mainly on citizen denunciations of violators and as a result is haphazard, especially in remote areas.

3. Key Findings

In this section, we discuss the methodology and key findings for each of our five research questions.

3.1. Before the coffee crisis (in 1993), what factors explained spatial patterns of deforestation in shade coffee forests?

Methods. To analyze pre-1993 deforestation patterns, we assembled a geographic information system (GIS) that included detailed, spatially explicit data on the characteristics of the study area. Table 1 lists the variables in our GIS, including units, sources, scale, and date. The variables are grouped into five categories: land cover, institutional, geophysical, socioeconomic, and agronomic. Data in the latter four categories were obtained from existing databases compiled by the sources listed in Table 1. In collaboration with the Basic Science and Remote Sensing Initiative (BSRI) laboratory at Michigan State University, the RFF–UMAR team generated land cover data using highly detailed 1993 aerial photographs of the study region (Figure 2).

Table 1. Variables in RFF–UMAR GIS

Variable	*Description*	*Units*	*Source*	*Scale*	*Date*
Land Use					
CLEAR_1	Land cleared?	(0/1)	INEGI/ERDAS	2 m pixels	1993
CLEAR_2	Land cleared, 1993–2001	%	USGS/ERDAS	Town	1993–2001
Institutional					
COOP	Coffee growers in cooperatives	%	CECAFE	Municipio	1991
EJI_COM	Ejido/Comunidade land held in common	%	INEGI[a]	Municipio	1991
PARK	In protected area?	(0/1)	SEMARNAT	1:1,000,000	1998
Geophysical					
COF	Altitude 400–1,600 m?	(0/1)	NIMA	30 arc seconds[b]	—
N_FACE	North facing?	(0/1)	NIMA	30 arc seconds	—
ALTIT	Altitude	m	NIMA	30 arc seconds	—
SLOPE	Slope	degrees	NIMA	30 arc seconds	—
MTNS	Terrain mountainous?	(0/1)	CONABIO	1:4,000,000	1992
HILLS	Terrain hilly?	(0/1)	CONABIO	1:4,000,000	1992
PLAINS	Terrain plains?	(0/1)	CONABIO	1:4,000,000	1992
DIST_CMKT	Travel time to north–south paved road	hours	ARCINFO	10 m pixels	—
DIST_TWN	Travel time to nearest town center	hours	ARCINFO	10 m pixels	—
DIST_CITY	Travel time to nearest big city	hours	ARCINFO	10 m pixels	—
SOILC_*	FAO soil types 1–6	(0/1)	CONABIO	1:1,000,000	1995
SOILT_*	FAO soil textures 1–3	(0/1)	CONABIO	1:1,000,000	1995
SOILF_*	FAO soil physical characteristics 0, 5, 6	(0/1)	CONABIO	1:1,000,000	1995
Socioeconomic					
POP	Population	none	INEGI[c]	Town	1995
POVERTY	Marginality index	none	INEGI	Town	1995
INDIG	Population indigenous	%	INEGI	Town	1995
Agronomic					
FSIZE	Coffee land on farms larger than 10 ha	%	CECAFE	Municipio	1991

[a]Ejido census.

[b]Approximately 1 kilometer.

[c]Population census.

Sources: INEGI = Instituto Nacional de Estadística Geografía e Informática (Mexico), ERDAS = image mapping software, USGS = U.S. Geological Survey, CECAFE = Consejo Estatal del Café de Oaxaca (Mexico), SEMARNAT = Secretaría de Medio Ambiente y Recursos Naturales (Mexico), NIMA = National Imagery and Mapping Agency (USA), CONABIO = Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (Mexico), ARCINFO = GIS software.

We hypothesized that some of the institutional, geophysical, socioeconomic, and agronomic characteristics of the study region might explain the observed 1993 spatial patterns of land cover. More specifically, characteristics that tend to lower the return to shade coffee relative to the return to land uses that require clearing—either by reducing the former or increasing the latter—promote deforestation. For example, all other things equal, clearing would be more likely to occur in areas underserved by coffee-marketing cooperatives because a lack of such cooperatives lowers the return to shade coffee. Thus, land uses that require clearing—e.g., conventional agriculture and logging—would be more attractive. We used multivariate regression analysis to identify those characteristics of the study area that best explained the 1993 patterns of land clearing. This technique and our results are explained in detail in Blackman et al. (2003).

Key Findings. All other things equal, we found that until 1993, inside the 400–1,600 msl coffee range, clearing was more likely to occur in areas

- far (in travel time) from the two coffee market cities of Oaxaca City and Pochutla. We believe such areas are more likely to be cleared because, as discussed above, growers there receive lower prices for their coffee.
- far (in travel time) from major urban centers. We hypothesize that such areas tend to be cleared for two reasons. First, because the region's roads are in poor condition, key inputs into coffee—notably, farm labor—are more expensive for farmers who live far from large cities. Therefore, such farmers earn lower profits on shade coffee. Second, in remote areas, laws restricting forest clearing are infrequently enforced by regulatory authorities headquartered in urban areas.
- near (in travel time) to town centers. We believe such areas tend to be cleared because towns are markets for agricultural inputs and outputs. Therefore, proximity to town centers boosts the return to land uses that require clearing.
- where few coffee farmers are organized into coffee marketing cooperatives. We believe that such areas tend to be cleared because farmers who are not members of cooperatives typically earn lower profits on shade coffee than those who are.
- where coffee farms are small. Anecdotal evidence suggests that the production and (especially) the marketing of shade coffee entail economies of scale, so small coffee farms earn lower returns than large farms.
- where indigenous peoples are prevalent. We believe such areas tend to be cleared because farmers who manage them do not have equal access to state-provided goods and services including education, technical extension, agricultural marketing, credit, and infrastructure. Hence, they are likely to earn relatively low profits from shade coffee.
- where a high percentage of land in *ejidos* is held in common instead of being parceled out to individuals.[1] We believe such areas tend to be cleared because the people who live and

[1] Group land holding institutions, *ejidos* have traditionally controlled most of the forested land in Mexico. Within *ejidos*, some land is typically parceled out to individual members, and some is held in common. Many, if not most, of the communal land holding institutions in our study area are *comunidades agrarias*, institutions very similar to, but legally distinct from, *ejidos*. For our purposes, the two types of institutions are identical and, therefore, for simplicity's sake, we ignore this distinction and refer to both as "*ejidos.*"

work there (known as *ejidatarios*) tend to use common land for shifting agriculture for two reasons: They do not pay the full costs of the degradation that results from shifting agriculture, and the value of nontimber forest products and ecological services associated with forest cover within the coffee range is relatively low (because these products and services are plentiful).

- at lower altitudes within the coffee range. We believe such areas tend to be cleared because they are better suited to growing conventional crops than to growing coffee (the best grades of coffee grow at higher altitudes).
- where land is not north facing. We hypothesize that such plots tend to be cleared because they receive more direct sunlight and therefore are better suited to growing conventional crops than to growing coffee.

3.2. Before the coffee crisis (in 1993), how did spatial patterns of deforestation in shade coffee forests differ from spatial patterns of deforestation in nearby natural forests?

To address this question, we relied on the GIS data described above. We used econometric techniques to determine whether there were any differences between: (i) the factors explaining spatial patterns of land use inside the 400–1,600 msl coffee range; and (ii) the factors explaining patterns of land use outside of this range. We found that

- all other things equal, the deforestation rate inside the coffee range was lower than that outside of it, undoubtedly because shade coffee preserves forest cover.
- within the shade coffee range, deforestation tends to occur on plots that are far from the one paved north–south road that provides growers with access to key coffee markets, whereas outside the coffee range, the opposite is true (Figure 2). We believe the reason is that all farmers—of shade coffee within the coffee range and of conventional crops outside the range—tend to locate near the north-south paved road to minimize the cost of transportation to and from market.

3.3. How much deforestation occurred in shade coffee forests after the onset of the coffee crisis (1993–2001)?

Methods. To measure changes in forest after the onset of the coffee crisis, we created new land cover data using LANDSAT satellite images from 1993 and 2001. These data cover a 241,000-hectare subset (95%) of the 254,000-hectare coffee range at 400–1,600 msl illustrated in Figure 2. For clarity, we refer to this subset as Study Area II.

Results. The new land cover data indicate that in Study Area II, 27,000 hectares of land that had been forested in 1993 were cleared by 2001. However, 19,000 hectares of land that had been cleared in 1993 were reforested by 2001. These figures imply a net loss of 8,000 hectares of forest cover, representing 3% of Study Area II (Figure 3). A good deal of this deforestation occurred in clusters near the region's one north–south paved road in an area of dominated by forest cover, whereas the reforestation was spread along the edges of existing agricultural areas to the west.

Our land cover data imply a 0.4% average annual deforestation rate between 1993 and 2001 in Study Area II. This rate was lower than national and state rates for similar time periods. The average annual deforestation rate for all of Mexico during the 1990s was 1.1% (World Bank 2002).

3.4. What factors explain spatial patterns of deforestation in shade coffee forests after the onset of the coffee crisis (1993–2001)?

Methods. To analyze changes in forest cover over time, we combined the LANDSAT-derived land cover data described in Section 3.3 with the GIS data described in Section 3.1. Next, we performed an econometric analysis to identify those characteristics of Study Area II that explain the spatial pattern of land clearing between 1993 and 2001.

Results. Because we continue to refine this particular analysis, the results reported here are preliminary. We find that, all other things equal, the highest deforestation rates occurred in areas that were

- near cities (in travel time). We believe such areas have relatively high deforestation rates for two reasons. First, when coffee prices decline dramatically, coffee farmers near big cities tend to abandon their farms because the cost of migrating to cities to find alternative sources of income is relatively low; abandonment leaves coffee farms vulnerable to encroachment by conventional farmers and ranchers. Second, conventional farmers and ranchers (sometimes former coffee farmers) locate close to large cities to minimize the costs of transporting inputs and outputs.
- on steep mountainsides. We do not yet have good hypothesis for this finding.

3.5. What drives farmers to abandon shade coffee plantations, and how can abandonment be prevented?

Methods. To learn more about the behavior of shade coffee farmers, we began by conducting interviews with farmers and collecting agronomic data on coffee production.

Together, these data suggested that abandonment is typically the last stage of a long downward spiral of falling incomes and yields touched off by an initial adverse price shock. When farmers first receive relatively low prices for their *pergamino*, they often migrate to cities to supplement their incomes with off-farm work. Away from their farms, farmers skip critical maintenance tasks—most important, pruning the coffee plants after harvest. The yields from poorly maintained coffee plants decline significantly and irretrievably. Decreasing yields will mean decreasing income in the future, even if coffee prices recover. Low profits force farmers to repeat this cycle of seeking off-farm work and skipping farm maintenance activities. Even one year of low prices can initiate such a downturn. Eventually, coffee yields (and profits) may drop so low that farmers are forced to abandon their plantations completely.

To identify the impact of various policies on farmers' abandonment decisions, we constructed a simulation model of farmer's maintenance, harvest, and abandonment decisions and examined how those decisions change with different price paths and policies in place. Details of this analysis have been presented elsewhere (Albers et al. 2003).

Key Findings. We find that coffee plantations are more likely to be abandoned when

- farmers have limited accumulated wealth;
- farmers have limited access to credit;
- coffee prices are highly variable;
- prices, yields, or both are so low that farmers lose money if they harvest; or
- prices, yields, or both are so low that farmers find it difficult to meet subsistence levels.

Several policies reduce the likelihood that farmers will start on the downward spiral that eventually leads to the abandonment of their plantations:

- **Credit** enables farmers to remain on their farms so they can perform maintenance activities during bad price years. However, constraints on the ability of farmers to repay loans—particularly if prices stay low for several consecutive years—can limit the feasibility of such a policy.
- Farmers who receive a **price premium** for their coffee—for example, high-quality coffee or coffee certified and marketed as shade grown or bird friendly—are likely to maintain their farms.
- Like a price premium, a **price floor** (guaranteed minimum price) for coffee (set fairly close to median coffee prices) encourages growers to maintain their farms.

- Projects and technical **agricultural extension activities** can increase the plantation productivity.

Although all of these policies can reduce the likelihood of abandonment, the timing of any policy determines its effectiveness. On shade coffee plantations, the decision to abandon is typically the result of the downward cycle described above. By the end of this cycle, coffee yields are so low that the policy interventions described above have little impact on farmers' abandonment decisions. Therefore, for all the policies examined, waiting to implement the policies until after some farmers have abandoned their plantations reduces the impact of the policy by up to 97% compared to implementing the policy when farmers begin to forego maintenance activities. Hence:

- **Policies implemented quickly after price shocks** are far more effective in preventing abandonment than policies implemented after a downward cycle has begun.

4. Conclusions and Policy Implications

- **The coffee crisis has led to significant deforestation**. Our analysis of LANDSAT-derived land cover data reveals that 3% of the forest cover in the coffee-growing region of our study area was lost between 1993 and 2001.
- **Promoting shade coffee should preserve forest cover.** Our comparison of patterns of deforestation inside the coffee range at 400–1,600 msl with patterns of deforestation outside that range demonstrates that, all other things equal, forest cover is more plentiful inside the coffee range. Also, our analysis of LANDSAT-derived land cover data indicates that average annual rates of deforestation inside the coffee range were well below rates for natural forests in Mexico as a whole.
- **Promoting coffee marketing cooperatives should help to slow deforestation.** We found that prior to the coffee crisis, deforestation tended to occur in areas relatively underserved by coffee-marketing cooperatives, all other things equal.
- **Heavily indigenous areas may be good targets for policies aimed at slowing deforestation in regions where shade coffee is grown.** We found that prior to the coffee crisis, deforestation tended to occur in heavily indigenous areas, all other things equal.
- **Investments that reduce transportation costs in shade coffee areas will likely have countervailing impacts on deforestation.** We found that all other things equal, prior to the coffee crisis, deforestation tended to occur far from the main north–south paved road,

but after the crisis, it tended to occur close to this road. The first result implies that when coffee prices are relatively high, improved transportation investments may promote shade coffee, and therefore, forest cover. However, when coffee prices decline, the same investments may encourage coffee farmers to abandon their coffee farms, leaving them vulnerable to deforestation.

- **Any policy that enables coffee farmers to harvest and to perform maintenance on their plantations during bad price years can prevent abandonment.** Such policies include providing credit, price premiums, and agricultural extension, as well as establishing a price floor for coffee.
- **Policies aimed at preventing abandonment are much more effective when implemented early**—when farmers need support to harvest and to maintain their plantations—rather than late, when farmers have already begun to forgo these activities.

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Figure 1. Location of Study Area

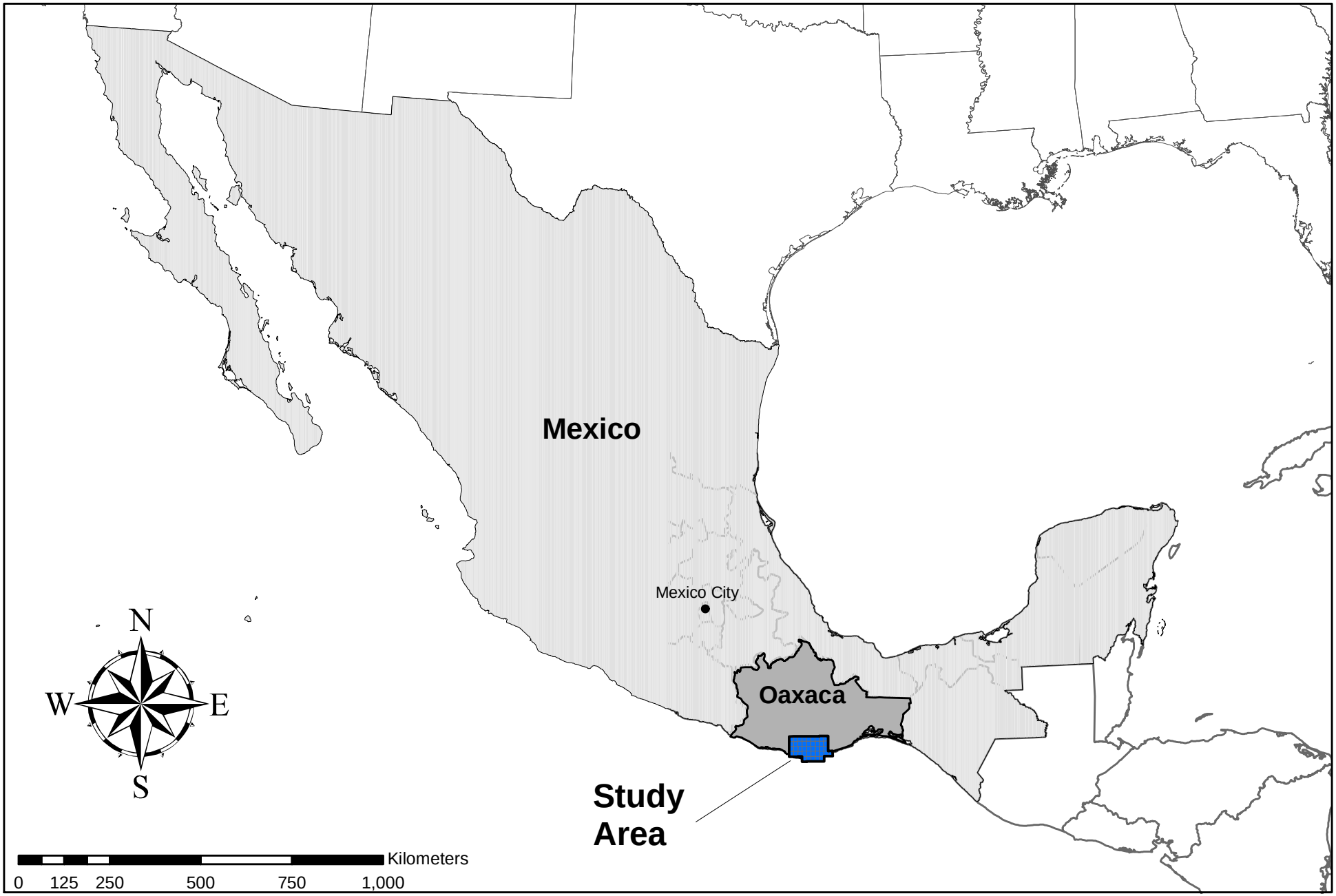

Figure 2.
1993 Land Cover (derived from aerial photos)

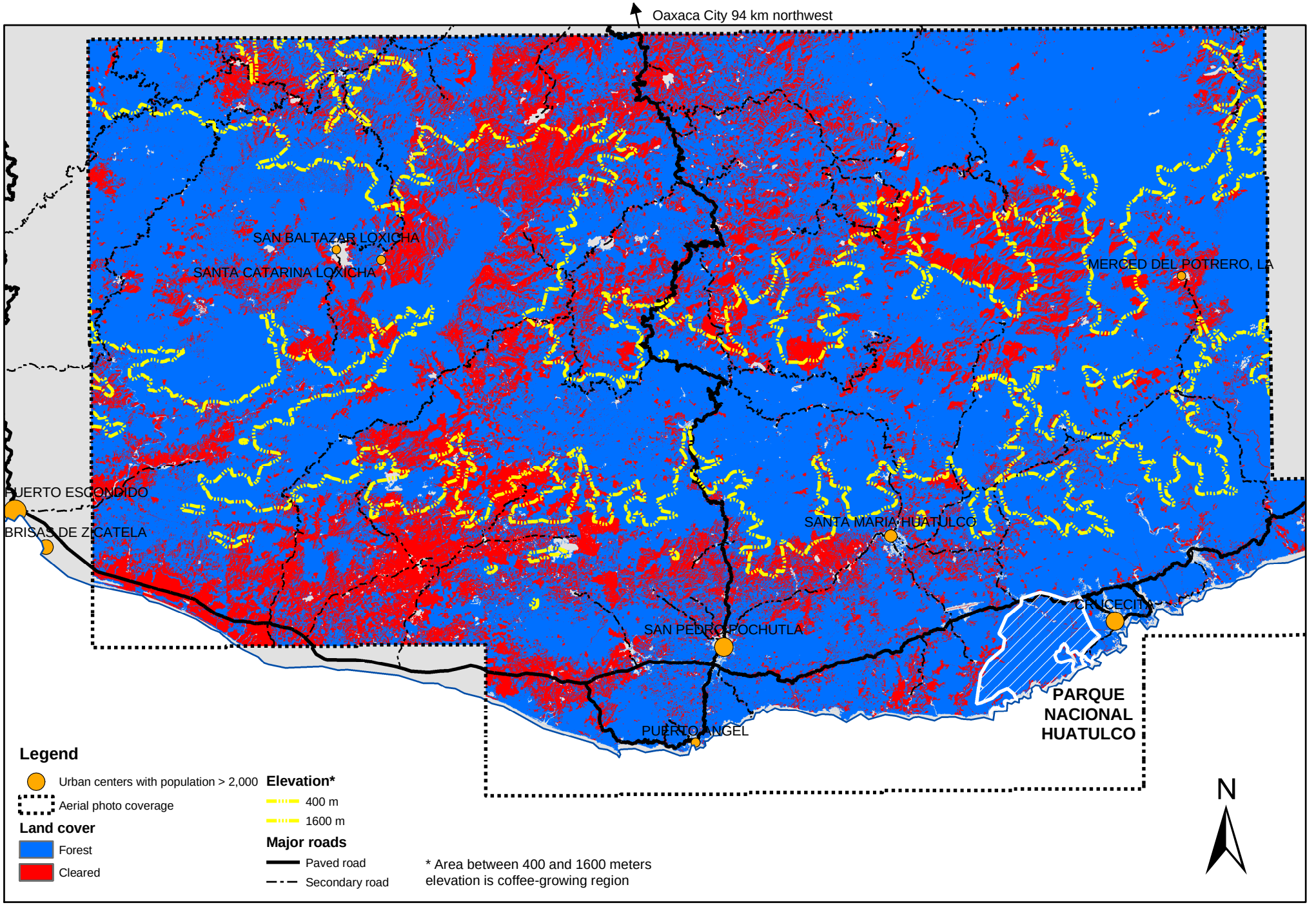
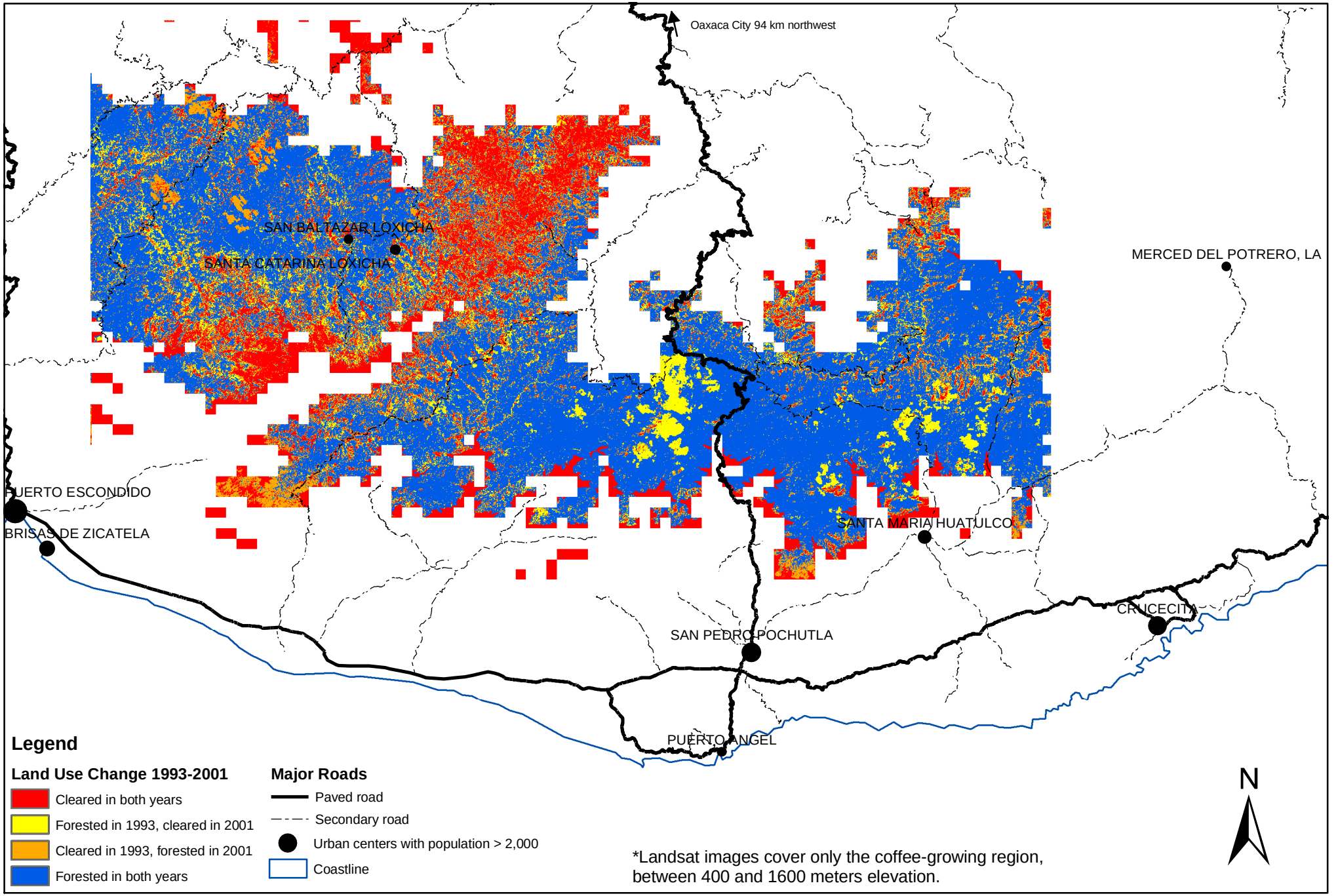
Figure 3.
Land Cover Changes 1993-2001 (derived from satellite images)